Weight System (EOWEP) for FPA-PM[1]
(An Abstract)

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February 4, 2005
Working Draft Version 2.5

What is a Weight?

In initial attack, a weight defines the importance of protecting different kinds of acres on the landscape. For example, if it is twice as important to protect acres containing sensitive habitat than it is to protect acres of rangeland, then protecting acres of sensitive habitat would count twice as much toward the effectiveness calculation used in FPA-PM. Weights are combined with information on resource costs, fire behavior and related data to inform and guide the optimization. Using weights is a common practice that has been used by previous and current fire management analysis systems. This paper explains the Expert Opinion Weight Elicitation Process (EOWEP) developed for FPA-PM.

The integrity of the weight system requires that weights only reflect the relative importance of protecting different kinds of acres from wildfire. Therefore, being clear about what weights are not is essential. For example, **weights differ from resource valuation.** Incorporating fire effects by fire intensity and seasonality enables EOWEP to focus on the relative importance of fire protection as opposed to resource valuation. A stand of large diameter, fire adapted ponderosa pine would have high value, but it may not be very important to protect from low or moderate intensity fires. The stand might even benefit from a low intensity fire. Similarly, depending upon the species, wildlife habitat might be important to protect only during a particular season. The weight system does not attempt to value the species or its habitat. Instead, resource valuation information from the land and fire management plans is used to inform and provide context for the weighting process. Also, weights are *not* **priorities or ranks** and they are not a means for **manipulating the outcome** of the FPA-PM process to arrive at a desired outcome.

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[1] This is an abstract of the EOWEP weighting system that is not intended to serve as a training document. Training materials have been separately prepared. The process for elicitation of fire protection attributes and their implicit prices is a central feature of EOWEP and needs to be conducted with appropriate care. Important information on the elicitation process is not addressed in this paper, but has been addressed in subsequent educational materials associated with training.

EOWEP in FPA-PM

FPA-PM is the first major system designed as a non-monetized application that conforms to the expectations that federal fire agencies use cost effectiveness analysis for program management planning[2]. Cost effectiveness analysis for performance based planning requires a physical measure of effectiveness such as acres protected or acres improved. Current land and fire management plans focus on a wide array of resources that can vary from FPU to FPU. We needed a weighting system that was flexible enough to include the full range of fire protection considerations across all five federal agencies while conforming to a program level performance measure. By making EOWEP an attribute based system it is able to reflect the specific conditions of the individual FPUs while establishing and supporting a program level metric of overall performance. This means that weights are based on the physical conditions of the landscape that reflect the major reasons that fire managers would engage in initial attack. These physical conditions of the landscape are described by a set of fire protection attributes. An acre might contain more than one attribute making it important to protect it from wildfire. For example, land might contain protection attributes such as: WUI, grazing, rangeland or historical structures. The weight system shows how these attributes are discerned and how they are used to arrive at per acre weights.

Expert Elicitation

The system relies on expert elicitation of protection attributes and implicit prices The expert is defined as the collection of fire managers, planners and resource managers necessary to provide information on initial attack and fire effects for assessing the relative importance of protecting different kinds of acres from wildfire.

Elicitation and Definition of Protection Attributes

EOWEP requires elicitation of a list of wildfire protection attributes reflecting the reasons that protection is important. A weight attribute for protection is defined as a ***physical*** characteristic of the landscape making it important to protect acres from wildland fire. Protection attributes are elicited from and defined by interdisciplinary experts on the planning unit and may reflect planning goals or objectives. Each attribute is measured in acres. Once the attribute list is elicited, all members must have a clear and consistent understanding of the meaning of each attribute before prices are elicited and before acres associated with the attributes are estimated. The weight team should develop a short paragraph for each attribute to document its meaning. Elicitation of the attribute list is the most important and likely the most difficult part of EOWEP so special care needs to be applied at this stage. Principles of attributes are defined in training materials associated with the FPA-PM training process.

Elicitation of Relative Values of Protection Attributes

Developing a common understanding of the protection attributes requires time and effort by the planning team. Each protection attribute is assessed relative to the other attributes by eliciting, for example, how important it is to protect acres of sensitive habitat relative to protecting acres containing structures such as homes. The fire protection attribute with the highest implicit attribute price (IAP) will normally be WUI and you will set this IAP to 1.00 as a benchmark from which to view the remaining IAPs. You may need to identify gradations of WUI such as high, medium and low density WUI. If so, each density level needs to be assessed, defined and

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[2] In principle it is possible to monetize the weights. While monetization would change the units of the weight system, it would not add functionality, resolve no known issues and it would potentially introduce negative side effects.

assigned an IAP. It is important that you define WUI to facilitate comparisons with other FPUs.
This means that definitions of WUI need to be clear so that comparisons can be made from FPU
to FPU. The process and rules for elicitation are central to the integrity of the weight system and
they are addressed in other materials.

Acre Inventory of Protection Attributes
After elicitation of the attribute prices, the planning team must take their list of attributes and
estimate and locate acres of each attribute that reside in the FPU. If an acre contains two
protection attributes, it is necessary to count it twice; once for each attribute. If an acre contains
no protection attribute, the acre is not counted.

Computation of Fire weights
We discuss two contexts for weight computation: 1. weights are applied to a collection of acres
such as the FMU (current method), and 2. weights are applied to the smallest geographic unit
such as an acre or pixel[3].

Method 1: Weights applied to the Fire Management Unit (FMU)
Method one requires that IAPs are averaged across the FMU according to the number of acres of
each attribute. Proper application of this approach requires that FMUs are designed as
homogeneous as is practical with respect to "high" and "low" priced attributes. This is because
distortions can occur when significant acres of "high priced" acres are combined with significant
acres of "low priced" attributes. Such distortion can occur because fires assigned to the FMU
receive the weight for the FMU which is an average. With high attribute value variability, the
average might not reflect either the high or the low priced attributes. Note that the FMUs in
Table 1 reflect this consideration. FMUs in Table 1 were constructed to be relatively
homogeneous with regard to variation in attribute values[4].

Protection Attribute	Management Unit			Attribute Price
	1	2	3	
Wilderness	40,000	0	1,000	**0.200**
Sequoia Groves	4,000	1,000	33,000	**0.750**
WUI	0	44,000	0	**1.000**
Fire Protection Value	**11,000**	**44,750**	**24,950**	
Burnable Acres	55,501	74,799	82,167	
Weights	**0.20**	**0.60**	**0.30**	

Table 1: FMU weight calculation example.

In Table 1 the acres for each protection attribute are multiplied by their attribute price (IAP) to
yield the value of protecting that attribute in the FMU. This is a non-monetized price. These
individual contributions to value are summed for each FMU to produce the intermediate
calculation of Fire Protection Value (FPV) for the FMU. The FPV is then divided by the number
of burnable acres in the FMU to provide a per acre weight. This is the weight for the FMU that
is applied to the integer program. This weight only has meaning when compared to the weight
calculated for another FMU. For example, if the weight calculated for FMU 1 was 0.20 and the

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[3] The optimization routine could be tailored to reflect either of these methods or variations on these methods such as
changing weights during the life of a fire.
[4] Also note that particular "points" of importance to protect are not reflected well in the analysis because the spatial
resolution (FMU) is broad.

weight for FMU 2 was 0.60, then we would interpret this as saying that it is 3.0 times more important to protect acres in FMU 2. An empirical example of FMU weight computations is shown in Table 1. Table 1 shows the list of elicited attributes in the first column followed by the number of acres of each attribute by FMU. The elicited IAPs are in the last column and their "currency" is in units of WUI acres—high structure density; the highest IAP in this example. Computations are as described above.

Method 2: Weights applied by acre or pixel

A stronger spatial analysis could improve the accuracy of weight calculations. Each attribute would be mapped across the FPU and a weight for each acre or pixel would be calculated by adding the attribute prices for the pixel. This value is then adjusted, if necessary, so that it is per acre. The per acre weights are then mapped as a separate GIS layer and applied to individual fires as they occur on the landscape. This method requires that fires are spatially located. We intend to provide an example of this method in a future paper.

Incorporating Wildland Fire Use (WFU)

As part of expanding the fire management paradigm to include a broader range of response options, we now address the concept of initial response. Initial response includes the range of management alternatives from initial attack through wildland fire use (WFU). WFU refers to naturally ignited fires that are desirable to manage because they produce overall, beneficial effects. Because the management and production relationships of WFU events are problematic to model, FPA-PM models the WFU event as a discrete, predefined event who's size, duration and complexity is estimated prior to optimization. Acres burned by the WFU event, on average, are considered to be beneficial, but not all acres are equally beneficial. Therefore, a weight is applied to the WFU event in the same way as for initial attack fires. Think of this as occurring in the steps described in the paper "Steps for Incorporating Wildland Fire Use in EOWEP."

Threat Fires

This section is an aside and can be skipped unless threat fires are important on your FMU. The term "Threat Fires" refers to fires that would occur outside of the FPU but would be considered for initial attack because they might burn onto the FPU and cause damage. These fires do not belong to any other FPU. They can be assigned to a "Threat FMU" that is adjacent to a regular FMU as in the following figure. Fires in the threat FMU would receive the same weight as the adjacent regular FMU with a potential downward adjustment that would need to be elicited. Such fires could be entered into the optimization with arrival times, weights and other elements associated with the threat FMU. There is no need to work directly with attributes for threat FMUs because deployment is not for the purpose of protecting acres in the threat FMU, but for protecting the adjacent regular FMU. Also acre estimates of the threat FMU are not used for calculating the threat FMU weights, because these weights are directly entered based upon the non-threat FMUs.
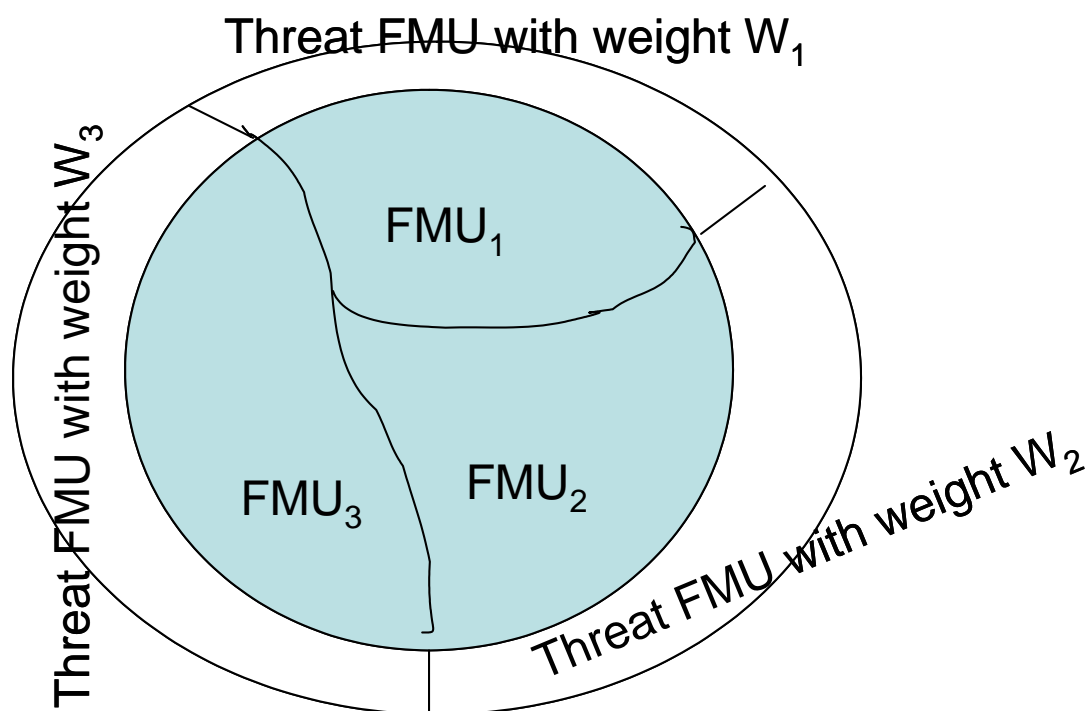
Figure 1. Weights for threat FMUs.

Discussion

The Expert Opinion Weight Elicitation Process (EOWEP) relies on establishing, documenting and evaluating the reasons why it is important to protect acres from wildfire. The strengths of this method are:

1. that when properly conducted it should be defensible and based on a sound application of economic theory.

2. that it relies on local information at the FPU level while supporting a programmatic measure of performance. In this way it bridges the "gap" between the local planning unit and the national program.

3. it provides a defensible and explicit structure to the considerations that have been important to fire managers. It thus enables them to make potentially better and more transparent decisions.

Elicitation and documenting well defined attributes and their prices is the crux of the process. This requires a clear understanding of the elicitation process, attribute definitions and comparisons by the planning team. There are many implications that are not addressed in this abstract, but one that should be mentioned is the concept of the FPU family. In the sense that a family shares the family income, the FPU shares the cost analysis and budget allocation (even though it may be broken out by agency). The construct of the FPU requires that the integer program and the budget allocation be performed across the entire FPU. When properly applied, EOWEP provides explicit, objective and defensible weights. Entities that cannot agree upon a

common set of attributes and IAPs may not belong in the same FPU. This is the nature of the FPU "sharing" a budget analysis and integer program run, and it is not a function of the weighting system.

Selected References

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